REMARKS

Claim Rejections Under 35 USC § 103

The Examiner has repeated his rejection of Claims 1 - 57 under 35 USC § 103(a), as being unpatentable over U.S. Patent No. 6,323,132, to Hwang et al., in view of U.S. Patent No. 6,094,334, to Bedi et al.

Applicants respectfully contend that their invention as claimed in independent Claims 1, 28, 33, and 44, and claims which depend therefrom are not obvious under a combination of the Hwang et al. And Bedi et al. references.

The subject application pertains to a method of pre-heating and then etching a surface of a semiconductor substrate where the surface is a metal-containing layer. In the past, preheating was carried out using ion bombardment with an inert gas, followed by etching of the metal-containing layer using a chemically reactive etchant plasma. However, the ion-sputtered deposits of the metal-containing layer which were created during plasma preheating were difficult to remove and the deposits affected the etch profile which was formed during etching. Applicants discovered that use of a preheating plasma which is sufficiently reactive with the metal-containing layer being preheated so that at least a portion of the sputtered deposits produced are different in composition from the metal-containing layer can enable the easy removal of the deposits during the etching of the metal-containing layer.

The '132 patent to Hwang et al. relates to a method of etching a platinum electrode layer, and the minimum etch temperature is the same as that specified in the present application for etching of platinum. However, the Hwang et al. reference teaches raising of the substrate temperature using heat exchange between the substrate and the underlying support pedestal. There is no mention of plasma preheating of the substrate prior to etch. The Bedi et al. reference discloses an electrostatic chuck having a resistance heater near the chuck surface for heating the substrate. The Examiner has argued that the Bedi et al. reference teaches heating of the substrate using plasma ion bombardment. Applicants have contended that the overall teachings of the

Bedi et al. reference are against using ion bombardment heating, which is said to affect the etch characteristics of the material heated in this manner. However, even if the Bedi et al. reference is interpreted as teaching that ion-bombardment preheating of the substrate may be used, there is no suggestion that the plasma source gas used to produce the preheating plasma contain a gas which produces species which are slightly reactive with the substrate surface. There is no suggestion that the plasma preheating step be designed to produce sputtered deposits containing compounds which enable easy removal of the deposits during subsequent etching of the preheated substrate. A combination of the teachings in the Hwang et al. reference with the teachings of the Bedi et al. reference will not lead in the direction of applicants' invention as claimed in amended Claims 1, 28, 33, 44, and claims which depend therefrom.

In detail, applicants' invention pertains to a method of pre-heating and then etching a surface of a semiconductor substrate where the surface is a metal-containing layer. The example metal-containing layers contain platinum, ruthenium, or iridium, which all require a relatively high temperature etch processing conditions. Due to the high temperature required during the etch process, it is necessary to preheat the substrate. In the past, preheating was carried out using ion bombardment with an inert gas, followed by etching of the metal-containing layer using a chemically reactive etchant plasma. However, the ion-sputtered deposits of the metal-containing layer which were created during preheating were difficult to remove from the surface of the metal-containing layer without affecting the profile which was being etched. During their experimentation, applicants used nitrogen, which was presumed to be inert with respect to platinum, to form a preheating plasma, and subsequently discovered that deposits formed during the preheating were easily removed during the etching of the platinum layer which followed. The preheating deposits were not easily removed when argon was used to form the preheating plasma. An investigation as to why this was happening showed that the deposits formed during preheating using a nitrogen-based plasma were not pure platinum, but contained limited amounts of a compound of platinum and nitrogen.

From this discovery, applicants developed the concept of using a preheating gas which was slightly reactive with the surface being preheated so that at least a small amount of a compound which was easily etched in the chemically etchant plasma (used subsequently to etch the substrate) would be present in the deposits. This enabled easy removal of the deposits during the etching of the substrate. To the best of applicants' knowledge, this concept was not known or used prior to applicants' discovery.

In applicants' method as claimed in Claim 1, the pre-heating is carried out using a plasma which is sufficiently reactive with the metal-containing layer that a metal-containing deposit or residue formed during the preheating has an overall composition which is different than the metal-containing layer to be etched, whereby the deposits or residues are more easily etched than the metal-containing layer during the etching step. The deposits or residues are removed during subsequent etching of the metal-containing layer.

The '132 patent to Hwang et al. relates to a method of etching a platinum electrode layer, and the minimum etch temperature is the same as that specified in the present application. However, the substrate temperature is raised using heat exchange between the substrate and the underlying support pedestal. There is no mention of plasma heating.

In particular, the '132 patent to Hwang et al. discloses a method of etching a platinum electrode layer disposed on a substrate to produce a semiconductor device including a plurality of platinum electrodes. (Abstract) According to the '132 patent disclosure, prior to etching the platinum electrode layer, the substrate must be heated to a temperature greater than about 150°C. Referring to Col. 21, line 66, through Col. 22, line 8, of Hwang et al.: ". . . before the platinum electrode layer 16 is etched, the semiconductor substrate 12 supporting the platinum electrode layer 16 is heated to a temperature greater than about 150°C . . . <u>The semiconductor substrate 12 is heated by the pedestal which supports the wafer 10 during the platinum etching process</u>." The '132 patent to Hwang et al. says nothing about heating the substrate by exposing the substrate to a preheating plasma, as claimed by applicants.

Bedi et al. discloses an electrostatic chuck for holding a substrate in a process chamber comprising an electrostatic member comprising a polymer covering an electrode, the polymer having a receiving surface for receiving the substrate. A heater abutting the polymer is provided to heat the substrate during processing of the substrate. The heater has a resistance that is sufficiently low to heat the substrate without causing excessive thermal degradation of the polymer. (Abstract)

Bedi et al. is cited by the Examiner as teaching heating of a substrate using a preheating plasma. The Examiner finds that applicants' argument with respect to the overall teachings Bedi et al. teaching away from plasma preheating due to a change in the etch characteristics of the substrate is not persuasive. Even if this were true, and even if one skilled in the art decides to try plasma preheating of the substrate, the Bedi et al. reference is silent as to composition of a preheating plasma; and, to the best of applicants' knowledge, other references in the art teach the use of an inert gas in general for plasma heating for lower temperature etch applications.

Applicants' invention is not disclosed by a combination of the Hwang et al. and Bedi et al. references, since neither of these references teaches that the plasma used for preheating should generate compounds which are more easily etched that the metal-containing layer which is to be etched after preheating of the substrate.

In the "Response to Arguments" section of the present Office Action, the Examiner further states: ". . . it is true that Hwang et al do not teach that the substrate is exposed to a pre-heating plasma but it would have been obvious to pre-heat the substrate with the plasma, which is used to etch the metal layer because plasma it self [*sic*] heat the substrate to a range of about 100 to about 250 degree C as supported by Bedi et al." However, applicants are not using the same plasma to both preheat and etch the substrate. The plasma used to etch the substrate must be far more aggressive than the preheating plasma or the etch rate will be economically non-viable. Further, the Bedi et al. reference does not disclose any particular gases for use in plasma

substrate preheating and makes no mention of using a plasma source gas which will enable easier removal of deposits or residues formed during the substrate preheating process.

There is no mention of applicants' invention as presently claimed, and as described in their Specification at Page 7, lines 22 - 25, continuing at Page 7, lines 1 - 20, which includes the following: " To enable removal of a preheating sputtered/etched material residue, the plasma source gas used to generate the preheating plasma may provide a plasma which is slightly reactive with at least the exposed layer to be subsequently etched." . . . . . "Once the combination of gases to be used during the patterning etch step has been determined, the particular plasma source gas to be used during the preheating of the substrate is selected. The plasma source gas for substrate preheating may be a single gas or a combination of gases, but needs to include at least one gas which is at least slightly reactive with the substrate material to be etched. Preferably, the plasma source gas for generation of the substrate preheating plasma contains at least one gas from the combination of etchant plasma gases used in the subsequent etching of the substrate material, as this simplifies processing requirements." . . . . . "Further, this inventive method is not focused on eliminating the sputtering of material during a substrate preheating step, but rather is focused on removing the material that is sputtered during the preheating step during the pattern etching step." Clearly the plasma used for preheating is different from the plasma used during the etch step.

For the reasons given above, even if one were to combine the teachings of Hwang et al. with those of Bedi et al., one would not arrive at applicants' claimed invention. Whether taken alone or in combination, neither Hwang et al. nor Bedi et al. teaches or even suggests applicants' claimed invention. In light of the above distinctions, applicants respectfully request withdrawal of the rejection of Claims 1 - 57 under 35 USC § 103(a) over Hwang et al., in view of Bedi et al.

Applicants' attorney contends that the amendments requested herein place the claims in better condition for allowance or for appeal and the Examiner is respectfully requested to enter the amendments. Further, applicants contend that all of the presently pending claims are in condition for allowance, and the Examiner is respectfully requested to pass the application to allowance.

The Examiner is invited to contact applicants' attorney with any questions or suggestions, at the telephone number provided below.

Respectfully Submitted,

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